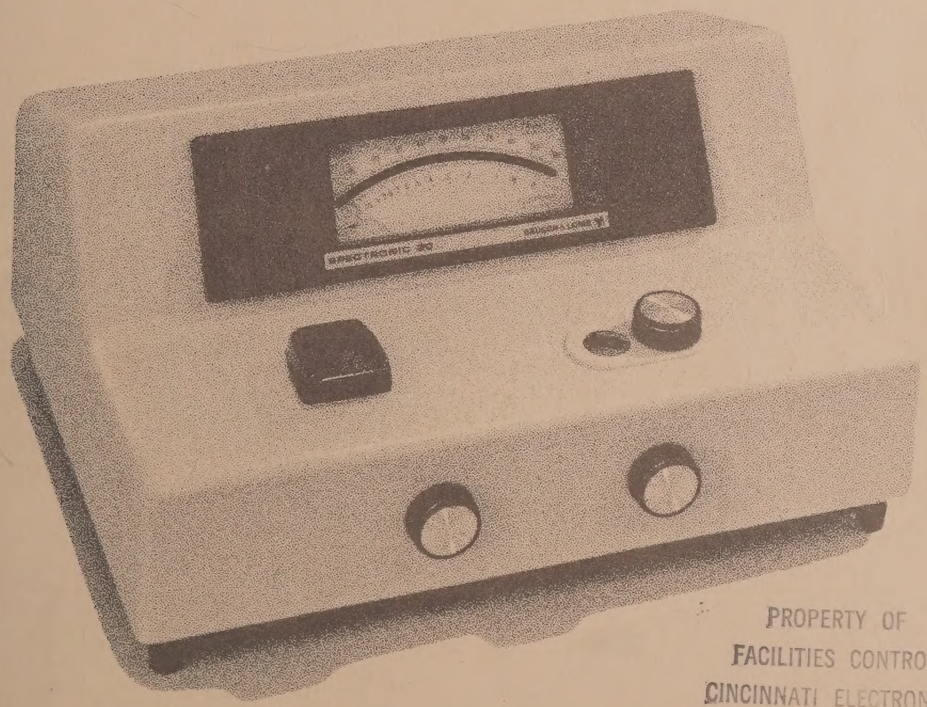
BAUSCH & LOMB
ANALYTICAL SYSTEMS DIVISION

(1)

PROPERTY OF
FACILITIES CONTROL
CINCINNATI ELECTRONICS
COPY _____

THE BAUSCH & LOMB
SPECTRONIC 20
SPECTROPHOTOMETER



PROPERTY OF
FACILITIES CONTROL
CINCINNATI ELECTRONICS
COPY _____

OPERATOR'S MANUAL

THE BAUSCH & LOMB SPECTRONIC 20 SPECTROPHOTOMETER

Cat. Nos. 33-31-71 and 33-31-72

OPERATOR'S MANUAL

SIXTH EDITION

SECOND PRINTING

BAUSCH & LOMB
ANALYTICAL SYSTEMS DIVISION
820 LINDEN AVENUE, ROCHESTER, NEW YORK 14625

TABLE OF CONTENTS

	PAGE
INTRODUCTION	3
Warranty	5
Responsibility For Safe Delivery	5
Specifications	6
DESCRIPTION	7
Models	7
Optics	7
Electronics	8
Controls	8
OPERATION	9
General	9
Phototube Options	9
Phototube Changeover	9
Basic Operating Procedures	11
MAINTENANCE	12
Source Lamp Replacement	13
Phototube Replacement	13
Line Voltage Conversion	13
Wavelength Calibration Check	14
Photometric Linearity Check	15
Operators Service Chart	16
Service Procedure	17
ACCESSORIES	18
Color Analyzer Reflectance Attachment	18
Microcell Adapter Assembly	27
Semi-automatic Flow-Thru Assembly	28
Concentration Computer	29
Recorder and Patch Cords	29
Filter Kit	30
PUBLICATIONS	32
ACCESSORY AND PARTS LIST	34
REGIONAL SERVICE CENTERS	Inside Back Cover

INTRODUCTION

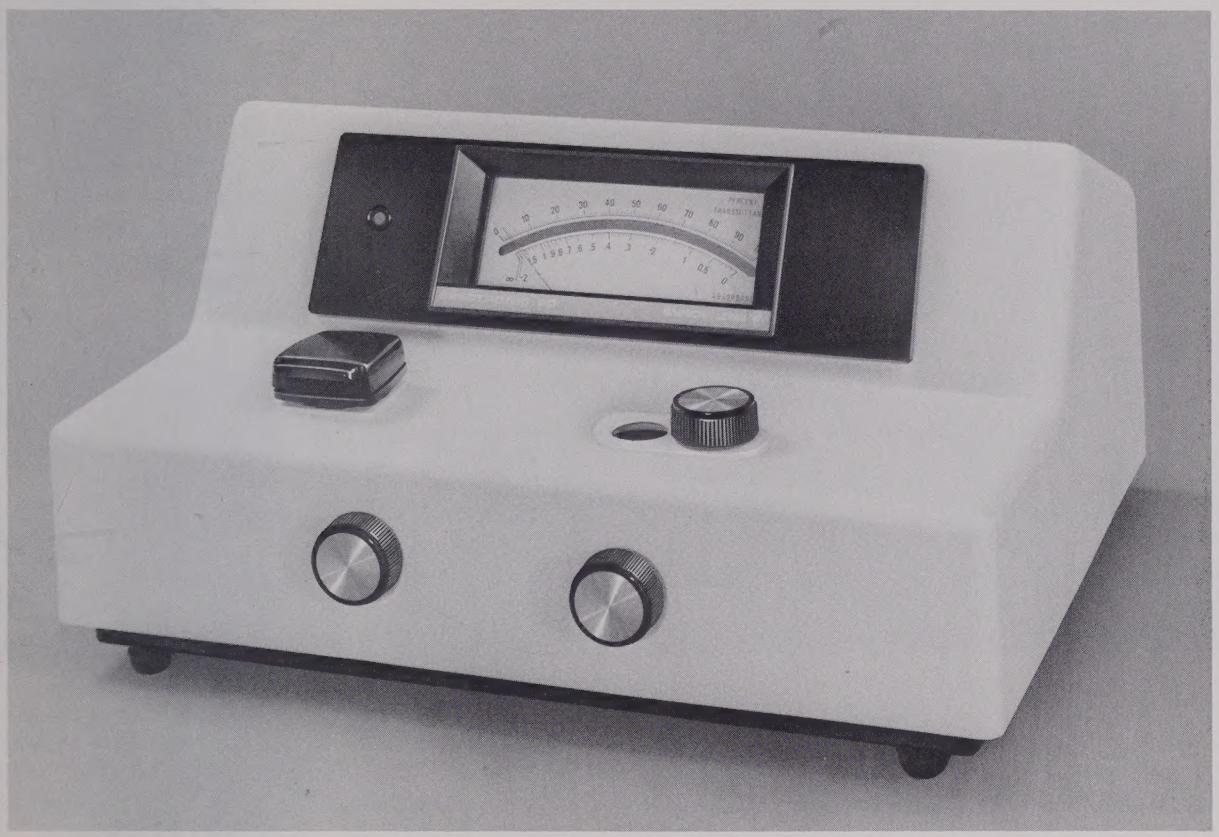


FIG. 1 - THE BAUSCH & LOMB SPECTRONIC 20 SPECTROPHOTOMETER

The Spectronic 20

The Spectronic 20 is a single-beam spectrophotometer with an overall wavelength range of 340nm to 950nm. The nominal spectral slit width is 20nm, constant over the entire range. With the Color Analyzer Reflectance Attachment, the Spectronic 20 may also be used for color analysis.

Full Scale deflection can be obtained over the basic wavelength range of 340nm to 600nm; by adding a red filter and interchanging phototubes, the range can be extended to 950nm. A special phototube (33-29-89) and filter (33-29-92) combination provides continuous operation from 400nm to 700nm without changing filter or phototube.

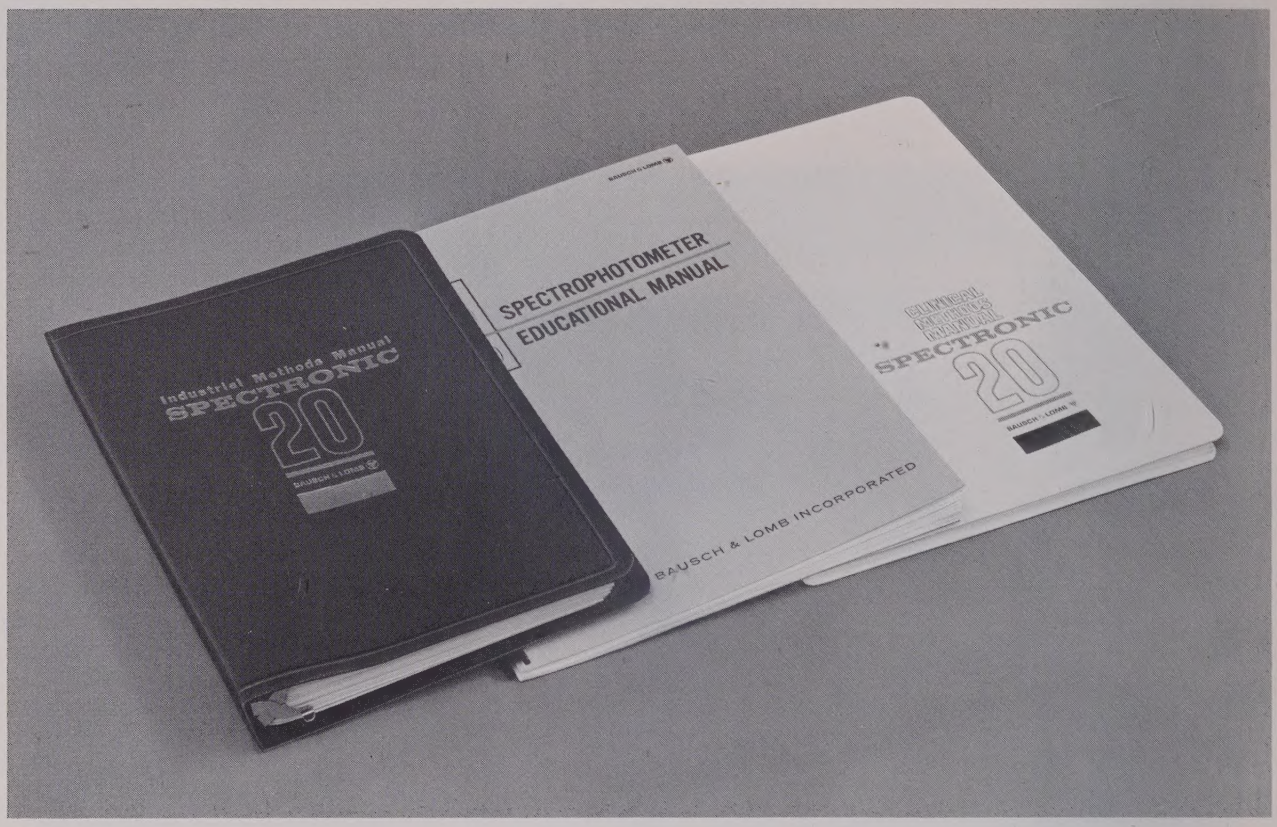


FIG. 2 - SPECTRONIC 20 APPLICATIONS MANUALS

B&L Publications

To help you get the most out of your Spectronic 20, Bausch & Lomb has available a Spectronic 20 Educational Manual, a Spectronic 20 Clinical Methods Manual, and a Spectronic 20 Industrial Methods Manual. General information on the theory and applications of spectrophotometers is contained in our "Fundamentals of Spectrophotometry" and "Introduction to Spectroscopy." Refer to the Publications section.

Published References

The Spectronic 20 Spectrophotometer is in use throughout the world and has been referred to in many published papers. Many of these articles deal with the development of new methods or with new applications of existing colorimetric techniques.

Warranty

Bausch & Lomb Analytical Systems Division instrumentation and related accessories are guaranteed to the consumer against defects of material and workmanship for a period of one year from date of installation. To validate this guarantee, the registration card must be returned within 15 days of purchase.

Responsibility for loss in operating performance due to environmental conditions such as humidity, dust, corrosive chemicals, deposition of oil or other foreign matter, spillage, or other conditions beyond our control cannot be accepted by Bausch & Lomb. Instrumentation in this category may be restored to original operating condition upon issuance of purchase order to cover labor, expenses and/or replacements of parts.

This guarantee covers all parts (except those referred to below) and shipping expense from Rochester, New York. The guarantee applies only to instruments and accessories which have been installed and operated in accordance with instructions in our reference manuals, have not been tampered with in any way, misused, suffered damage through accident, neglect or conditions beyond our control, and have been serviced only by our authorized dealers or Analytical Systems Division service personnel.

Lamps, glassware, electronic tubes, photodetectors and similar expendable components are exempt from this guarantee and carry the warranty offered by the component manufacturer.

There are no other warranties, express or implied, and we shall not be liable under any circumstances for consequential damages.

Responsibility For Safe Delivery

Packaging is provided for all Bausch & Lomb products to protect them from normal transportation hazards and assure their safe delivery.

After the product leaves the factory, responsibility for its safe delivery is assumed by the transportation company handling the shipment.

If your shipment shows evidence of rough handling, request the party making the delivery to note "received in bad order" on your delivery receipt. If concealed damage is revealed after the shipment is unpacked, contact a representative of the transportation company and request that a bad order report be made out.

SPECIFICATIONS

WAVELENGTH RANGE:	340nm to 950nm (with accessory filter and phototube)
WAVELENGTH ACCURACY:	Better than 2.5nm
WAVELENGTH READABILITY:	1.0nm (1/5 division)
WAVELENGTH PRECISION:	Better than 1.0nm
SPECTRAL SLIT WIDTH:	20nm, constant over entire range
STRAY LIGHT:	Less than 0.5% over full range (with appropriate filter)
METER LINEARITY:	± 1%
PHOTOMETRIC REPRODUCIBILITY:	± 1% of full scale
MONOCHROMATOR:	Reflection grating, 600 grooves/mm
REGULATION:	+ 1% of full scale for ± 10% line voltage change (regulated model)
READOUT:	Meter display, 5-1/2 inch mirrored scale. Calibrated in percent transmittance and absorbance units. Digital and graphical readout accessories available for the Regulated Model ONLY.
DETECTORS:	Standard Phototube (33-29-71), 340nm - 600nm
	Accessory Phototube (33-29-72), with Red Filter (33-29-18), 600nm - 950nm
	Accessory Phototube (33-29-89) with Filter (33-29-92), 400nm - 700nm
DIMENSIONS:	16-1/4" W x 13-1/4" D x 8-1/4" H 41.5Cm x 33.8Cm x 21Cm
WEIGHT:	Approximate Net - 17 lbs., 7.7 kg. Approximate Gross - 24 lbs., 10.9 kg.
POWER REQUIREMENTS:	100, 115, 220, 240 volts, 50/60 Hz, 90 V.A. (Regulated Model)
	115 volts, 60 Hz ONLY, 35 V.A. (Standard Model)

DESCRIPTION

Cat. No. 33-31-71

STANDARD MODEL, 340nm - 600nm, for 115VAC, 60 Hz ONLY, including 12 selected 1/2" diameter test tubes, 1/2" test tube adapter, dust cover, and instruction manual. It is recommended for use where the variation of line voltage and/or frequency is less than 1%.

Cat. No. 33-31-72

REGULATED MODEL, 340nm - 600nm, for 100, 115, 220, 240VAC, 50/60 Hz, including 12 selected 1/2" diameter test tubes, 1/2" test tube adapter, dust cover, and instruction manual. It is recommended for use where variations in line voltage and/or frequency may interfere with operation, or when the user plans to use digital or graphic readouts with the Spectronic 20.

Optics

The operation of the optical system is shown below. White light from the tungsten lamp passes through the entrance slit and is focused by the field lens onto the objective lens. The objective lens focuses the image of the entrance slit at the exit slit after the light has been dispersed and reflected by the diffraction grating.

When setting the wavelength, a cam positions the grating so that only the desired wavelength passes through the exit slit. The monochromatic light which exits continues on through a sample contained in a test tube or cuvette placed in the light path. The monochromatic light beam terminates at the measuring phototube, where the light energy is converted to an electrical signal. When the sample is removed from the instrument, an occluder automatically falls into the light path, blocking all light from the phototube. The operator can then electronically adjust the instrument for a 0%T meter reading. A 100%T control is provided to set 100% transmittance (zero absorbance) with a reference solution in the sample holder.

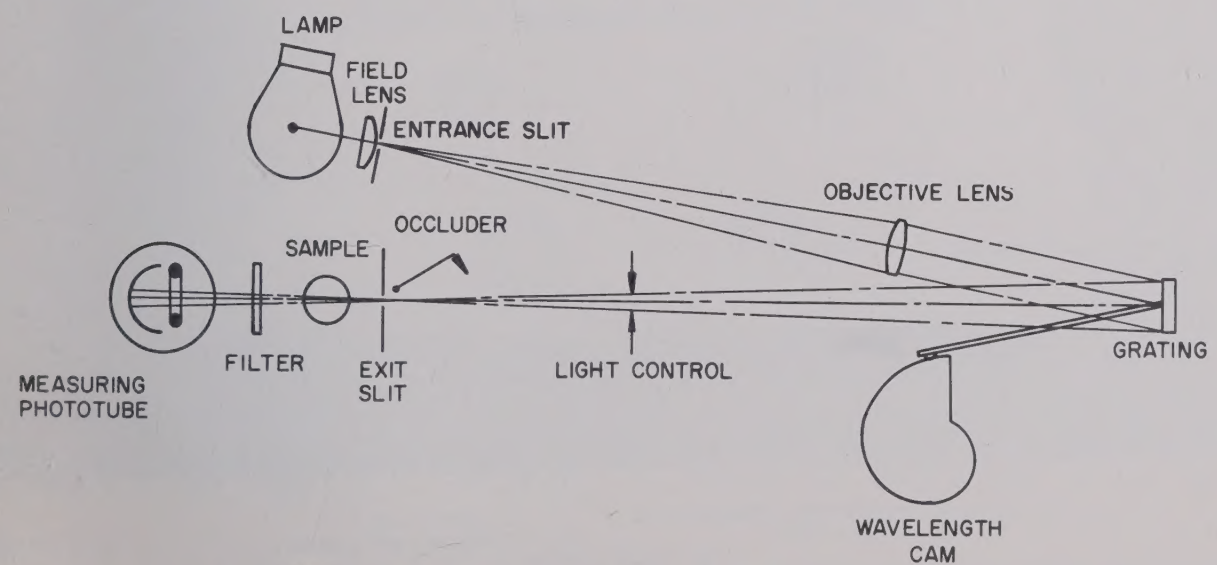


FIG. 3 - SPECTRONIC 20 OPTICAL SYSTEM

Electronics

The measuring circuit of the standard model consists of a DC differential amplifier with a current gain of 5,000. A zener diode serves as a phototube bias voltage regulator. The power supply, tube filament, and lamp voltages are regulated by a constant voltage transformer tuned to 60 Hz.

The regulated model is designed with reliable solid-state components for low maintenance and long-term stability. The entire electronic system (power supply, source lamp, phototubes, and amplifiers) have a high level of regulation using zener diode voltage stabilization and closed-loop feedback networks. The instrument can tolerate line voltage fluctuations of + 10% from nominal with a maximum meter drift of ± 1.0%T.

The accessory output signal is adjustable from 0.0 to 1.0 VDC at 100%T (with a resistive load of 100 kilohms) to provide better compatibility with a wide variety of accessory readout devices (recorders, concentration computers, etc.).

Controls

The Spectronic 20 has three main controls for routine operation:

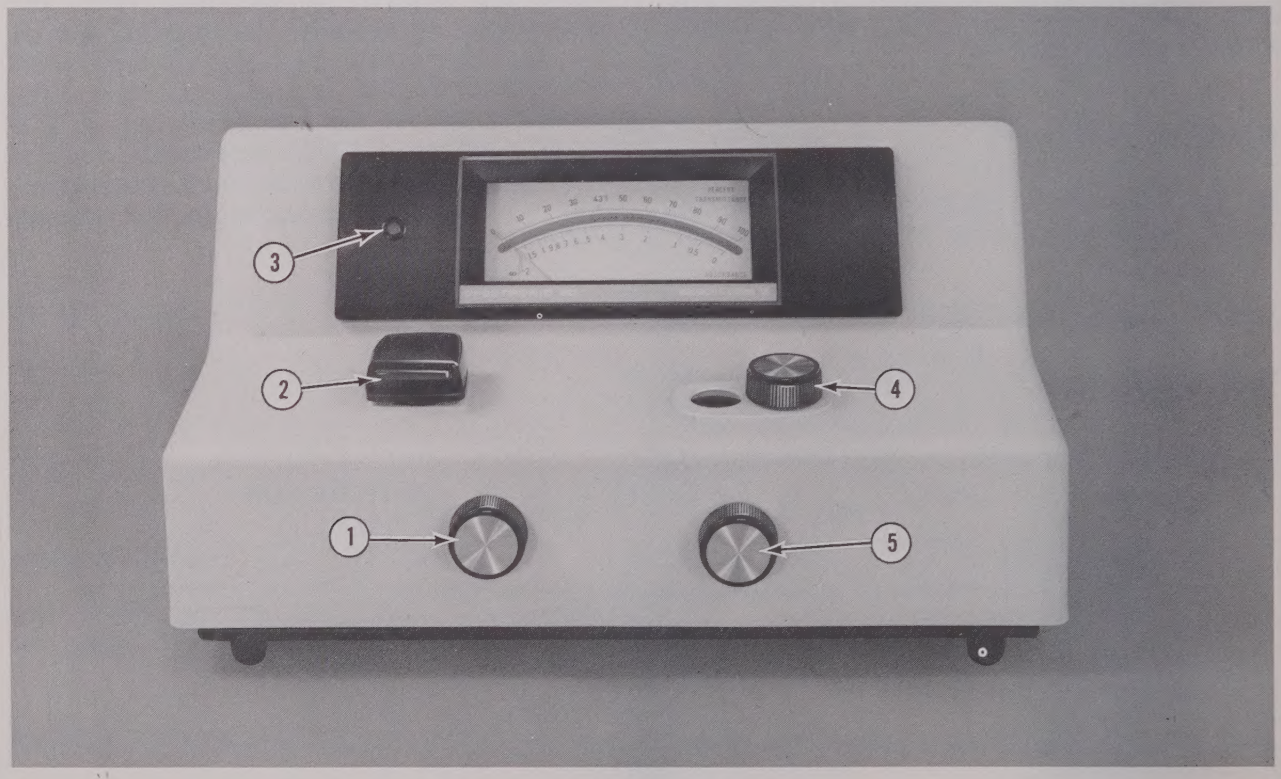
Wavelength Control

Power Switch / Zero Control

100%T Control

WAVELENGTH CONTROL

The Wavelength Control selects the desired analytical wavelength of the instrument. The selected wavelength is indicated on the Wavelength Scale in the window next to the knob. The Scale is color-coded to correspond to the operating range of the instrument's



1. Power Switch/Zero Control
2. Sample Holder
3. Pilot Lamp
4. Wavelength Control
5. 100%T Control

FIG. 4 - FRONT VIEW

phototube: Black gradations for the basic 340nm - 600nm range, and red gradations for the 600nm - 950nm range of the optional red phototube/filter combination. All gradations are in 5nm intervals.

POWER SWITCH/ZERO CONTROL

The ON-OFF main power switch is operated by the Zero Control Knob.

The Zero Control is used to set the meter to a 0%T readout WHEN THE TEST TUBE ADAPTER IS EMPTY AND THE ADAPTER COVER IS CLOSED.

100%T CONTROL

This control is used to set the meter to 100%T (0.0A) with a blank reference solution. IT MUST BE RESET WHENEVER THE ANALYTICAL WAVELENGTH HAS BEEN CHANGED. When operating at a fixed wavelength for an extended period of time, periodically check the 100%T (and 0%T) readout and readjust if necessary.

OPERATION

General

The Spectronic 20 Spectrophotometer features uncomplicated adjustment and operation. However, successful use of the instrument requires close attention to correct laboratory procedures and analytical techniques, i.e., clean glassware, correct dilutions, etc.

1. All solutions must be free of bubbles.
2. All sample holders must be at least 1/2 full.
3. For greater accuracy, use square cuvettes, Cat. No. 33-29-33.
4. For optimum performance with test tube sample holders, insure that the index mark on the tube aligns with the mark on the adapter.
5. During extended operation at a fixed wavelength, make an occasional check for 100%T meter drift.

Sample Adapters For:	Adapter Cat. No.
Standard 1/2" Test Tubes	33-31-27
Accessory 3/4" Test Tubes	33-29-31
Accessory 1" Test Tubes	33-29-30
Micro-Cell	33-29-14
Square Cuvette, 1/2"	33-29-49

To change adapters, loosen the small set screw on the inner wall of the adapter, using the Allen wrench clipped to the bottom of the instrument.

Phototube Options

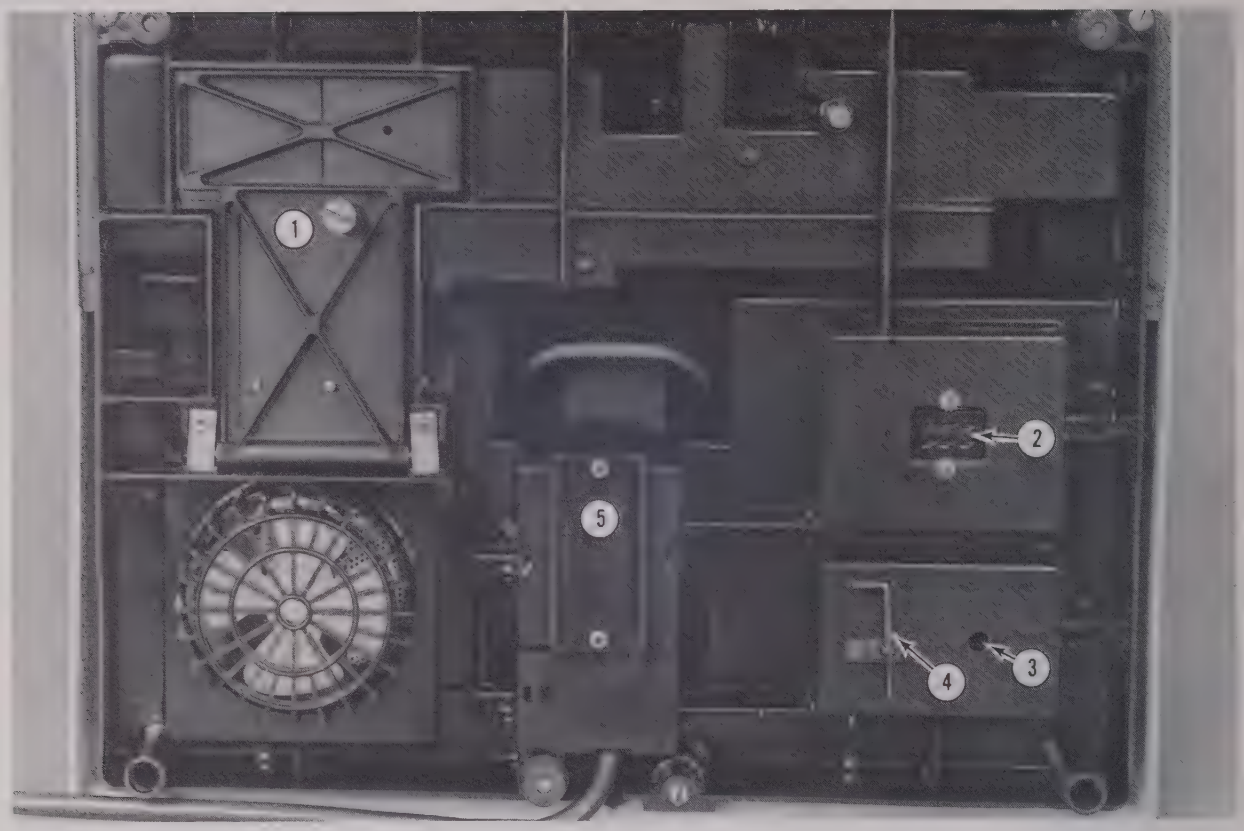
The operating wavelength range is determined by the particular phototube/filter installed in the instrument:

Range	Phototube Cat. No.	Filter Cat. No.
340-600nm	33-29-71	N/A
600-950nm	33-29-72	33-29-18*
400-700nm	33-29-89	33-29-92*

* or appropriate filter from the Accessory Filter Kit (33-31-28)

Phototube Changeover

1. TURN OFF AND UNPLUG THE INSTRUMENT.
2. Tilt up the unit and set on its back.
3. Loosen the thumbscrew on the lamp access door and open the door.
4. Remove the phototube using the plastic gripper as an aid.



1. Lamp Access Door
2. Analog Output Jack
3. Analog Output Adjustment
4. Adapter Wrench
5. Line Voltage Switch

FIG. 5 - BOTTOM VIEW

5. Install the tube and plastic gripper. If a filter is required, insert into the holder on the inside of the door. The tube and filter must be clean and free of all fingerprints.

6. Close the door and securely fasten the thumbscrew. THIS IS ESSENTIAL FOR PROPER OPERATION.

1. Phototube
2. Source Lamp
3. Filter Holder

FIG. 6 - LAMP COMPARTMENT

BASIC OPERATING PROCEDURES

Preliminary

1. Install required adapter, select sample holder.	As required
2. Select phototube/filter	As required
3. Power ON - 5-minute warmup	Power Switch (Zero Control)

Sample Measurement

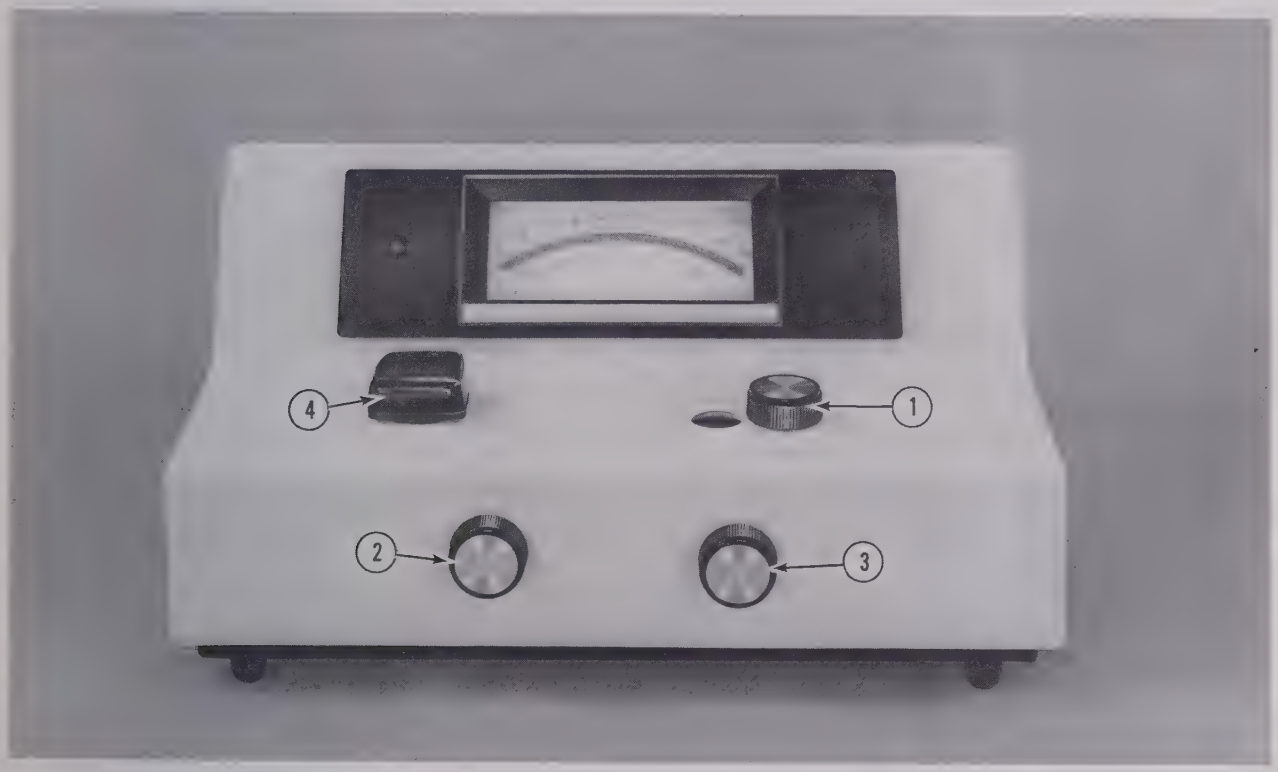


FIG. 7 - SAMPLE MEASUREMENT

1. Select Wavelength	Wavelength Control
2. Set meter zero*	Zero Control
3. Insert reference blank, set 100%T (0.0A)	100%T Control
4. Insert unknown sample, readout in %T or Abs.	Meter Display

* Sample compartment empty, cover closed.

NOTE: For added convenience, the self-stick instruction plate may be attached to the right side of the meter bezel to provide ready reference to the proper controls and procedures.

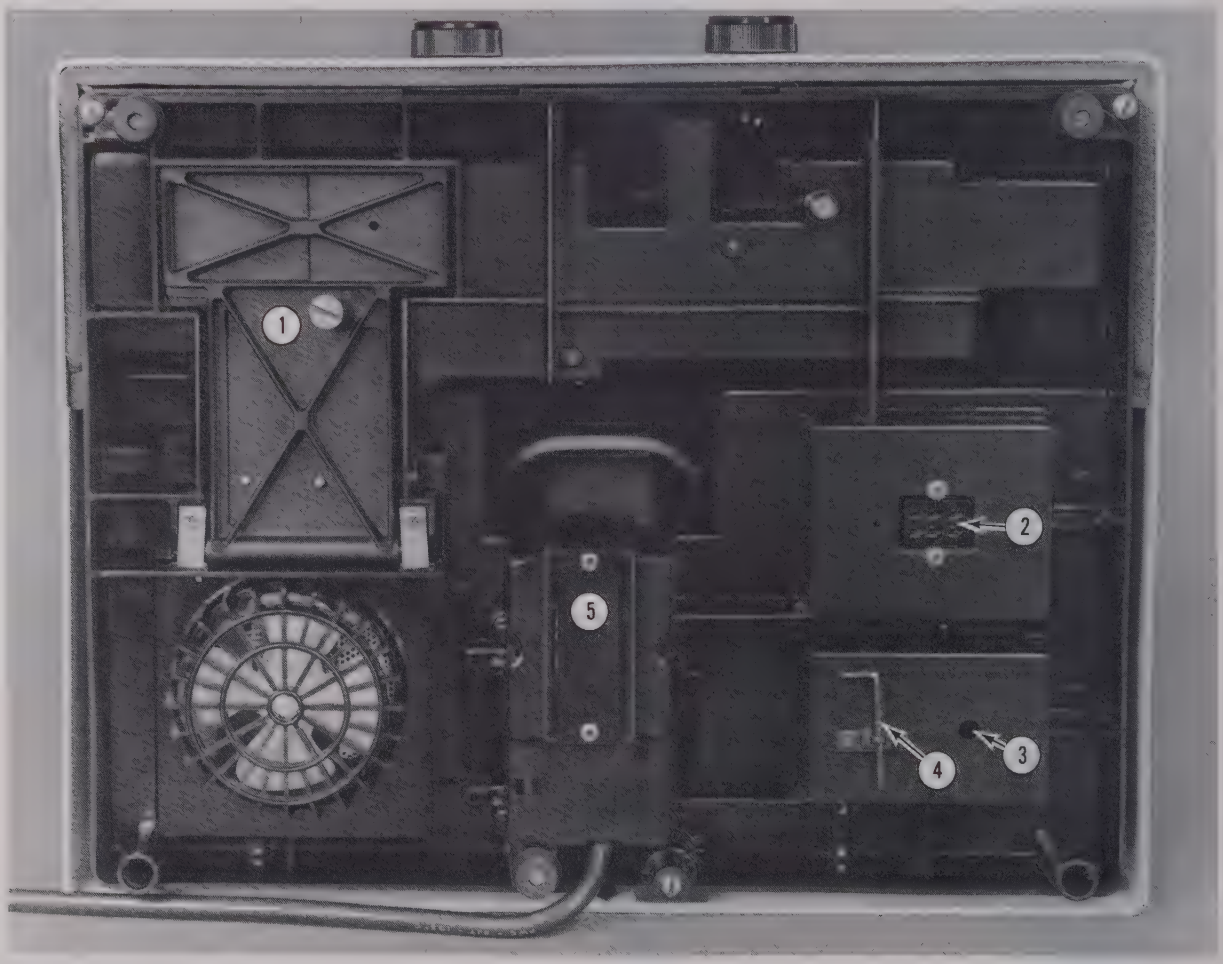
MAINTENANCE

The Spectronic 20's functional design, simplicity and reliability have been field proven and tested in over 90,000 instruments. Routine customer maintenance has been reduced to the replacement of the source lamp and phototube.

Routine checks for wavelength calibration and photometric linearity, as well as line voltage conversion, can also be done by the operator.

For the protection of both the operator and the instrument, it is highly recommended that instrument repair or maintenance beyond the scope of this section be performed by qualified dealer or Bausch & Lomb service personnel. Refer to the "Service Procedure."

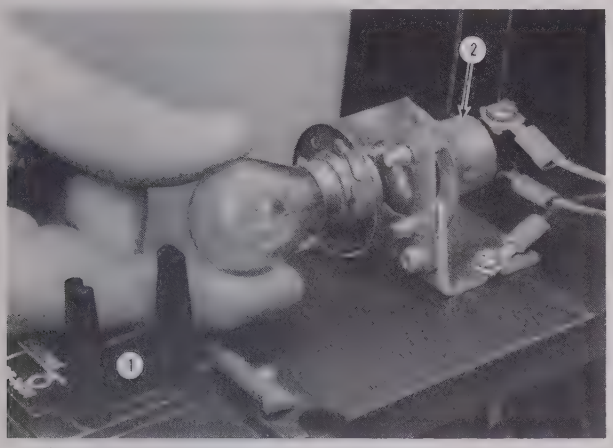
NOTE: A service manual, Cat. No. 33-31-46, is available to those technically qualified to perform electronic servicing.



1. Lamp Access Door
2. Analog Output Jack
3. Analog Output Adjustment
4. Adapter Wrench
5. Line Voltage Switch

FIG. 8 - BOTTOM VIEW

Source Lamp Replacement



1. Filter Holder 2. Lamp Socket

FIG. 9 - SOURCE LAMP REPLACEMENT

1. TURN OFF & UNPLUG THE INSTRUMENT
2. Tilt up the unit and set on its back.
3. Loosen the thumbscrew on the lamp access door and open the door.
4. Using finger pressure, press the lamp socket toward the mounting flange. Rotate the lamp CCW and remove.
5. Install the new lamp, use LIGHT finger pressure on the socket and rotate lamp CW until secure.
6. Clean the lamp envelope, close the door, and tighten securely. THIS IS ESSENTIAL FOR PROPER OPERATION.

Phototube Replacement

1. TURN OFF & UNPLUG THE INSTRUMENT
2. Tilt up the unit and set on its back.
3. Loosen the thumbscrew on the lamp access door and open the door.
4. Remove the phototube using the plastic gripper as an aid.
5. Install the tube and plastic gripper. The tube must be clean and free of all fingerprints.
6. Close the door and securely fasten the thumbscrew. THIS IS ESSENTIAL FOR PROPER OPERATION.

1. Phototube 2. Source Lamp 3. Filter Holder

FIG. 10 - LAMP COMPARTMENT

Line Voltage Conversion

(Regulated Model 33-31-72 ONLY)

The Regulated Model Spectronic 20 contains a multiple-tap power transformer for operation on 100, 115, 220, 240VAC, 50/60 Hz. A voltage selection switch is used to adapt the instrument to the available line voltage. The switch is accessible through a cover plate located on the bottom of the instrument.

CAUTION

UNPLUG THE INSTRUMENT BEFORE PROCEEDING.

FIG. 11 - LINE VOLTAGE SELECTION SWITCH

1. Tilt up the instrument and set on back panel.
2. The switch cover plate is located in the lower center of the base. Remove the two screws and the plate.
3. Set the switch to the proper voltage position.
4. Replace the cover plate and change the line cord plug if required.

NOTE: The proper line fuse is automatically selected with the switch.

Wavelength Calibration Check

The Spectronic 20 should retain its wavelength accuracy for the life of the instrument under normal operating conditions. If the instrument is subjected to a severe shock or other abuse, you may wish to check the wavelength accuracy. There are two alternate methods for this check:

If you have the Spectronic 20 Filter Kit accessory, Cat. No. 33-31-28, superior results will be obtained using the didymium calibration filter. Refer to the "Accessories" section. If the didymium filter is not available, use the following cobalt solution:

a) 1% Hydrochloric Acid

Place 400ml distilled water in a 1-liter volumetric flask. Add slowly and with caution, 10ml concentrated HCl (ACS grade). Mix and make to volume with distilled water.

b) Cobalt Chloride Stock Solution

Place 22-23gm cobalt chloride (ACS) in a 1-liter volumetric flask. Dissolve and make to volume with 1% hydrochloric acid solution.

COBALT SOLUTION CHECK

1. Set 500nm Wavelength	Wavelength Control
2. Adjust Meter Zero (Sample compartment empty–Cover closed)	Zero Control
3. Insert distilled water, set 100%T	100%T Control
4. Insert Cobalt Chloride Stock Solution, Read %T	Meter Display

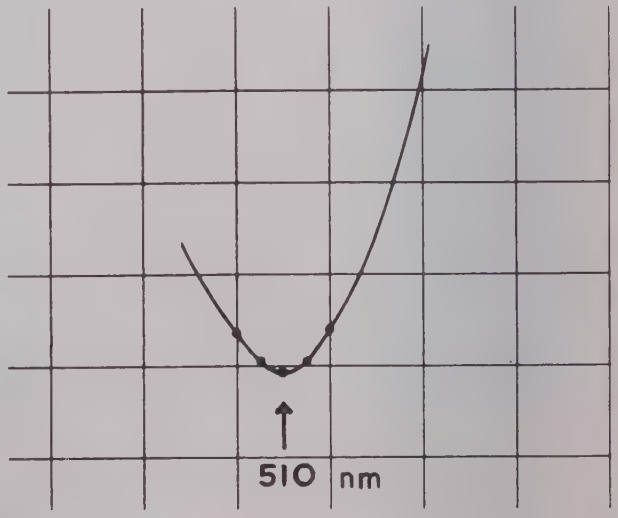


FIG. 12 - WAVELENGTH CALIBRATION CHECK

Repeat steps #2-4 at 505, 510, 515, and 520nm. The instrument is in proper calibration when maximum absorbance (minimum transmittance) occurs between 505 and 515nm. The specific absorbance values are unimportant.

WAVELENGTH CALIBRATION ADJUSTMENT

If the wavelength accuracy is out of tolerance, refer to the "Service Procedure" section. We do not recommend customer recalibration.

Photometric Linearity Check

If the photometric linearity of the instrument is questionable, first check your analytical procedure and technique. If proper operation is still in doubt, make the following check: (Refer to "Wavelength Calibration Check" for cobalt solution preparation.)

1. Install required adapter, select sample holder.	As required
2. Power ON - 15-minute warmup	Power Switch (Zero Control)
3. Set wavelength at 510nm	Wavelength Control
4. Adjust Meter Zero (Sample compartment empty–Cover closed)	Zero Control
5. Insert distilled water blank. Set 100%T.	100%T Control
6. Insert stock cobalt solution	NOTE ABSORBANCE VALUE

7. Dilute stock cobalt 1:1 with 1% HCl. Use care and accuracy in the dilution.

8. Insert 1:1 cobalt dilution–ABSORBANCE value must be 1/2 of stock solution (step #6), $\pm$ 2 divisions.

SPECTRONIC 20
OPERATOR'S SERVICE CHART

Instrument Inoperative

1. Line cord not connected to outlet.	
2. Dead power outlet.	
3. Source lamp burned out.	Replace with Cat. No. 33-33-85.
4. Phototube defective.	Replace as required.
5. Defective electronic component.	Refer to service manual or service agency.

Meter Won't "Zero"

1. Sample compartment cover not closed.	
2. Occluder binding.	Check occluder action.
3. Phototube defective.	Replace as required.
4. Defective electronic component.	Refer to service manual or service agency.

Meter Drift

1. Poor sampli g.	Bubbles or particles in solution.
2. Excessive line voltage variation.	Check voltage and grounding.
3. Wrong line voltage setting.	Reset line voltage selection switch.
4. Source Lamp defective.	Replace with Cat. No. 33-33-85.
5. Phototube defective.	Replace as required.
6. Meter defective.	Refer to service manual or service agency.
7. Defective electronic component.	Refer to service manual or service agency.

Cannot Set 100%T (OA)

1. Occluder closed.	Install test tube in sample compartment.
2. Sample holder not fully inserted into adapter.	Insert fully.

3. Improper filter installed.	Remove or change filter.
4. Source Lamp weak.	Replace with Cat. No. 33-33-85.
5. Wrong line voltage setting.	Reset line voltage selection switch.
6. Phototube weak.	Replace as required.
7. Wavelength Calibration error.	Check calibration.
8. Defective electronic component.	Refer to service manual or service agency.

Readings Not Repeatable (Meter Zero and 100%T OK)

1. Loose lamp access door.	Tighten thumbscrew.
2. Loose sample holder adapter.	Tighten set screw.
3. Poor analytical technique.	Dirty test tubes, bubbles, etc.
4. Meter sticking.	Tap lightly for possible correction.

Service Procedure

If the Spectronic 20 should develop a malfunction that cannot be corrected by operator maintenance, the instrument can be serviced by trained specialists at your dealer or Bausch & Lomb service center. To avoid unnecessary delays:

FIRST CONTACT THE DEALER FROM WHOM THE INSTRUMENT WAS PURCHASED.

If the warranty has expired, you may contact any B&L Field Service Center, listed at the rear of this manual. If it is necessary to ship the instrument:

1. Pack carefully in a crush-resistant carton with at least 3 inches of shock absorbing material to prevent transit damage.
2. Include a detailed letter inside the shipping carton, fastened to the instrument, describing the trouble. Please include the name and phone number of the person or department head most familiar with the problem. This information will enable service personnel to make required repairs promptly and at least expense.
3. Mark on the shipping container:

FIRST CLASS LETTER ENCLOSED.

First class postage will be required only on the letter. The carton will be accepted at standard mail rates.

ACCESSORIES

Color Analyzer Reflectance Attachment
Cat. No. 33-29-44-01

1. Power Supply 2. "Black Body"
3. Measuring Sphere

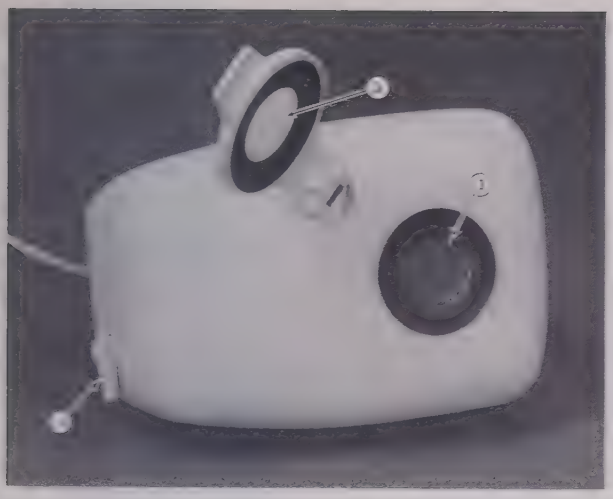
FIG. 13 - THE SPECTRONIC 20 REFLECTANCE ATTACHMENT

The Spectronic 20, when equipped with the Reflectance Attachment, will measure reflectance as a function of wavelength for a wide variety of materials such as paints, dyes, plastics, and textiles. The Reflectance attachment measures a sample surface area of approximately 2mm x 8mm; an alternate model (Cat. No. 33-99-5631) is available on special order for measurements of a 12mm x 12mm area. The smaller unit is adequate for general use. The larger sample area model is best suited for samples such as cloth, which have a rough, textured finish.

DESCRIPTION

The unit is shipped with the following components:

1. The measuring sphere assembly with interconnected power supply for 115VAC, 50/60 Hz only. The sphere contains a measuring aperture with cover, and a light shutter handle. The aperture cover contains a built-in secondary reference standard of white porcelain.



1. Light Shutter Handle 2. Porcelain Standard
3. Measuring Aperture

FIG. 14 - MEASURING SPHERE

The light shutter handle is on the left side and controls the light input to the phototube. When the handle is depressed, the shutter is open. The shutter will close automatically when the handle is released.

THE SHUTTER MUST BE CLOSED WHENEVER THE UNIT IS IN OPERATION AND THE MEASURING APERTURE IS EXPOSED TO ROOM LIGHT. PHOTOTUBE DAMAGE CAN RESULT IF THIS PRECAUTION IS NOT FOLLOWED.

2. A magnesium carbonate block is used as the primary white reflectance standard. This block is extremely fragile and must be handled with care. Keep wrapped in paper when not in use, and scrape lightly with a knife before use.

3. A "Black body" fixture, used as the 0% reflectance standard.

INSTALLATION

CAUTION

UNPLUG AND TURN OFF THE SPECTRONIC 20 AND THE REFLECTANCE ATTACHMENT POWER SUPPLY.

1. Remove the test tube adapter from the Spectronic 20.

2. Tilt up the instrument and set on its back. Loosen the thumbscrew on the lamp access door and open the door.

3. Remove the phototube, using the plastic gripper as an aid, and filter (if installed).

4. Feed the plug and cable from the measuring sphere through the test tube adapter hole on top, and plug into the phototube socket. Seat the measuring sphere onto the Spectronic 20 cover.

5. Route the measuring sphere ground wire around the outside of the instrument and place on the access door thumbscrew. Close and fasten the access door.

6. Connect the Spectronic 20 and the Reflectance Attachment power supply to a 115VAC, 50/60 Hz source. If the line voltage is 220/240 Volts, a separate step-down transformer must be used.

1. Attachment Plug 2. Ground Wire

FIG. 15 - INSTALLATION OF CABLES

(NOTE: If a 33-29-10 constant voltage transformer is used with a standard model Spectronic 20 Cat. No. 33-31-71, do not plug the power supply into it. Additional regulation of the attachment is not required.)

7. Turn on the units. (The power supply has a 10-second delay before the pilot light comes on.) Allow 5-minute warmup. For the first installation, or after a change of photomultiplier:

8. Set the Spectronic 20 Zero Control full-clockwise.

9. Adjust the control on the bottom of the Reflectance Attachment power supply for a 50% - 70% meter reading.

CALIBRATION OF WHITE PORCELAIN STANDARD

Reflectance measurements are comparison values based upon a 100% reflection setting taken from a magnesium carbonate block, the industry standard of white reflectance. The magnesium carbonate block is extremely fragile, however, and is unsuitable for routine, general purpose use. For this reason, a white porcelain "secondary" standard is built into the cover of the Measuring Sphere. The porcelain surface, after calibration, is used as an "Adjusted" 100% standard for all actual measurements. To calibrate, the reflectance of the porcelain is measured against the magnesium carbonate surface at the following standardized wavelengths:

415nm	565nm
445nm	595nm
475nm	625nm
505nm	655nm
535nm	685nm

These wavelengths are identified on the Spectronic 20 Wavelength Scale by diamond-shaped indice markers.

CAUTION

THE LIGHT SHUTTER MUST BE CLOSED BEFORE OPENING THE MEASURING SPHERE DOOR.

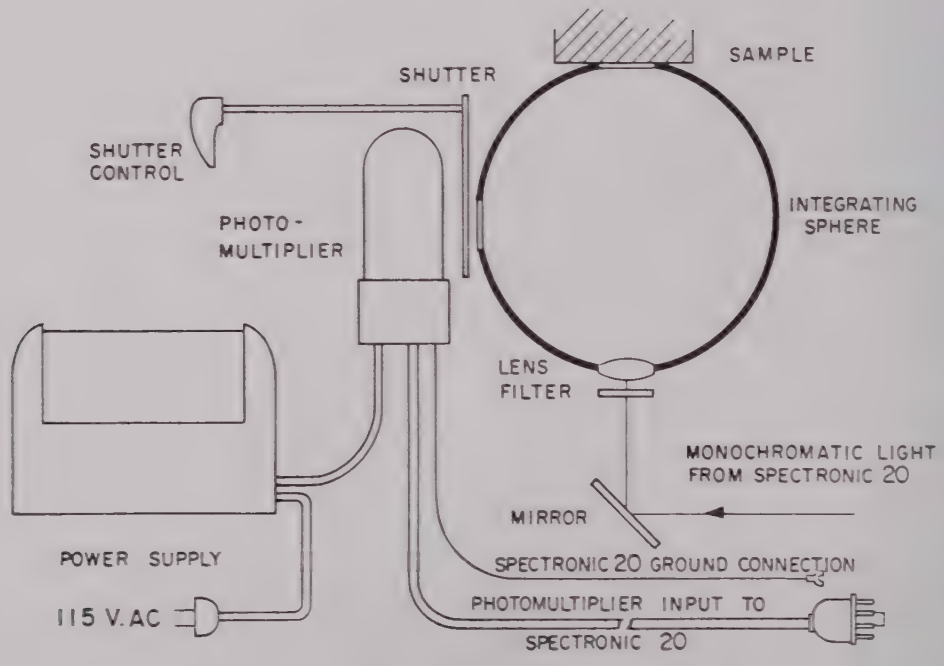


FIG. 16 - REFLECTANCE ATTACHMENT DIAGRAM

1. Select desired Wavelength	Wavelength Control	
2. Install "Black Body"	On Measurement Sphere Aperture	
3. Open shutter, set 0% reflectance (0%T)	Zero Control	
4. Remove "Black Body," install magnesium carbonate block		
5. Open shutter, set 100% reflectance (100%T)	100%T Control	
6. Remove magnesium carbonate, close aperture cover		
7. Open shutter, note % reflectance of porcelain. Repeat steps 1-7 for all standard wavelengths. The reflectance curves of the porcelain surface can now be plotted and used as an adjusted reference for sample measurements.		

NOTE: Whenever necessary, the white porcelain can be easily cleaned with a damp cloth and mild detergent. The internal lens at the bottom of the sphere must be wiped clean of any $MgCO_3$ particles.

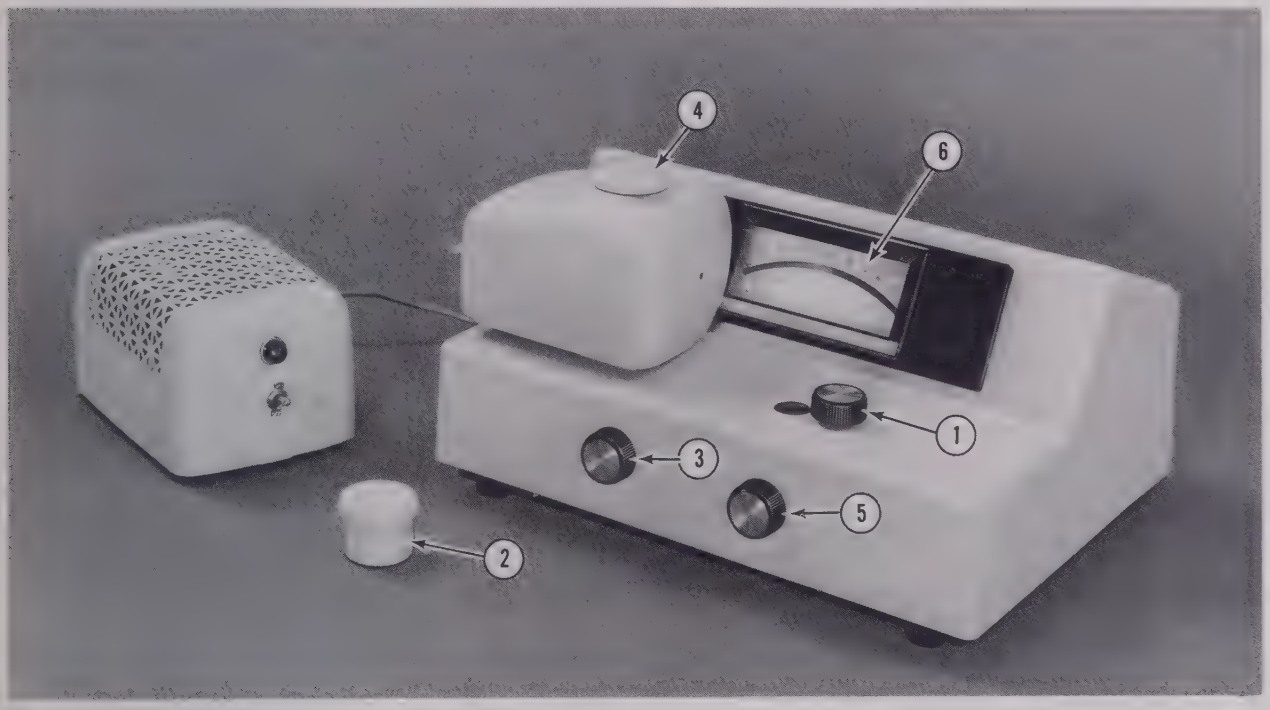


FIG. 17 - SAMPLE MEASUREMENT

SAMPLE MEASUREMENT

1. Select desired Wavelength	Wavelength Control	
2. Install "Black Body"	Measurement Sphere Aperture	
3. Open shutter, set 0% reflectance (0%T)	Zero Control	
4. Remove "Black Body," close aperture cover tightly.		
5. Open shutter, set meter to REFLECTANCE VALUE OF PORCELAIN STANDARD (see Calibration)	100%T Control	
6. Install sample, open shutter, read % reflectance.	Meter Display	

Color Determination

The determination of spectral reflectance is an important aspect of appearance specification. However, the apparent color of any material is a strong function of the viewing environment. The viewing environment of the Reflectance Attachment is a specialized one designed to measure total reflectance less part of the specular component. This will give readings closely related to appearance, but not necessarily the same as that of a different reflectance measuring instrument.

For best results, it is recommended that the errors due to the position or orientation of the sample be minimized. To obtain reproducible results on samples which show a preferred orientation such as weave, or on a sample which presents a non-uniform area, such as the convex surface of some pharmaceutical tablets, it may be necessary to resort to the use of a jig for holding the specimen in some particular position during measurement. Since this type of work is dependent exclusively upon the manufactured product, it will be necessary for each user to design and make his own jig to fit the specific application. We shall be glad to recommend specifications for these jigs whenever possible. Because of errors arising from these problems of surface variations, it is recommended that the standard always be measured under conditions similar to those of the specimen.

To specify a color, it would be awkward to give a spectral response curve for each color. A system has been developed for color specification which makes it possible to specify a color by three numbers. These numbers are called x, y, and Y. The value of x and y specify the location of the color on the "chromaticity diagram." The value Y indicates the brightness of the color.

A detailed explanation of the determination of tristimulus values may be found in "The Science of Color" by Thomas Y. Crowell Crowell Co., New York, in NBS Circular 478 on "Colorimetry," or "Principles of Color Technology" by Billmeyer and Saltzman. To facilitate the reduction of data taken from the Reflectance Attachment to x, y, and Y values, the "Bausch & Lomb Trichromatic Coefficient Computation Form for Illuminant C" may be used. Illuminant C is a standard representation of average daylight.

USE OF COMPUTING FORM

For an example of a filled out computing form, see Fig. 18. In the left column, opposite the standard wavelengths, are written the values of the reflectance reading of the porcelain standard that correspond to a 100% reading for the magnesium carbonate standard. After taking a reflectance reading as previously described (e.g., 415nm), a short vertical line should be drawn through each of the top scales opposite the wavelength number 415 in each of the three groups of wavelength numbers, at the correct value of that reading. This procedure should be repeated for the other wavelengths as the different readings are taken. It is then necessary to fill in (in the right-hand column) the readings opposite the standard wavelengths on each of the bottom scales as indicated by the vertical marks that were previously made.

It will only be necessary to do this to two digits after the decimal point. The numbers in the right column opposite the first group of wavelength numbers should be added and the sum written on the line designated TOTAL X.

The procedure should be repeated for the second and third groups to obtain values for TOTAL Y and TOTAL Z. By filling in the blanks at the bottom of the page and performing the indicated arithmetic, the three chromaticity coordinates are obtained.

To measure the reflectance of liquid samples, it is suggested that a glass cell

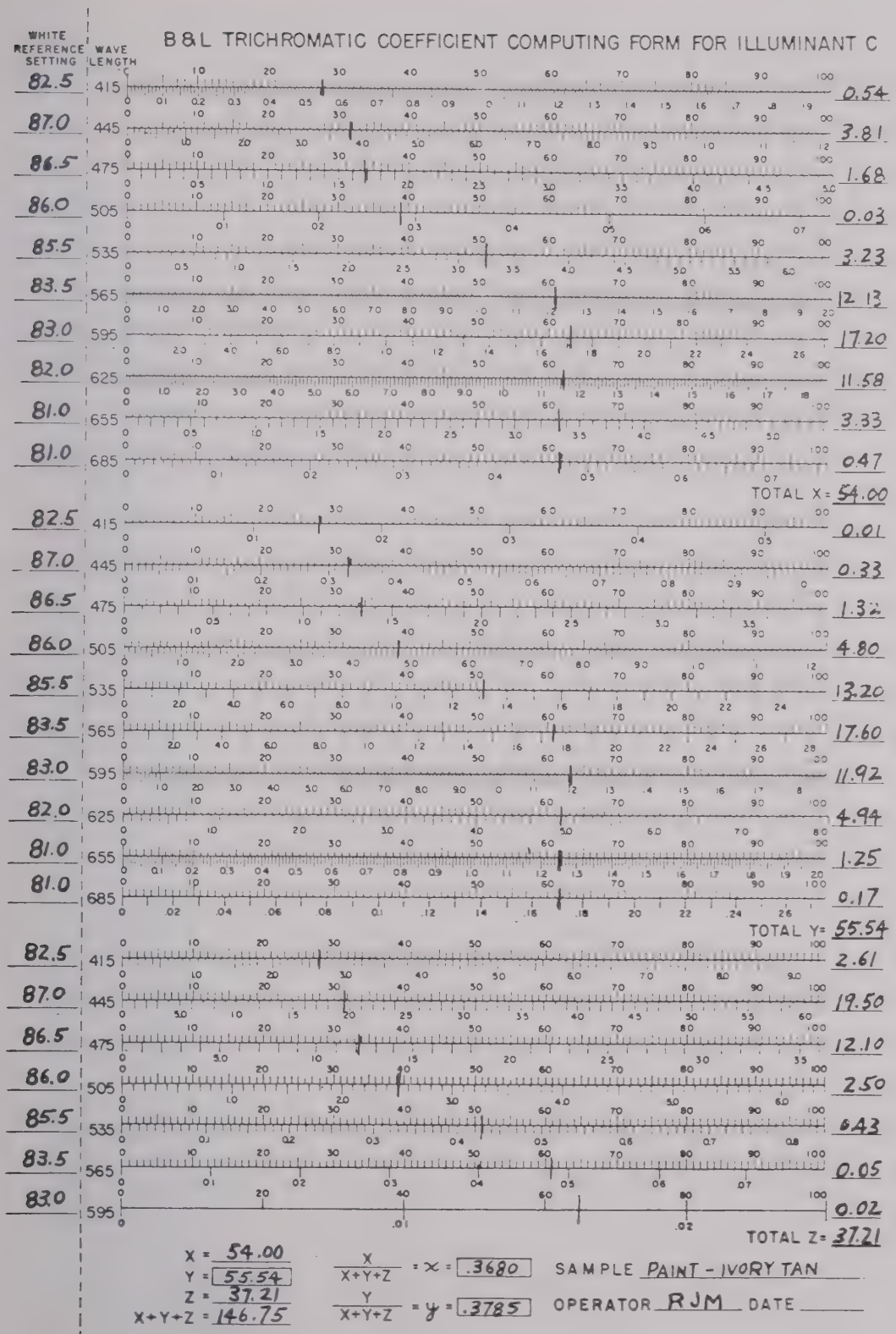


FIG. 18 - EXAMPLE OF TRICHROMATIC COMPUTATION

with a flat bottom of uniform optical properties be used. A cell similar to the American Instrument Company's 5-820 Cell is recommended for use in conjunction with the Bausch & Lomb 33-29-32 Light Shield. The liquid sample is placed in the cell, the cell is then set over the measuring aperture and the light shield is placed over the cell to prevent extraneous light from entering the measuring sphere. Measurements are taken in the same way as with solid samples. It should be remembered, however, that the reflectance of the glass cell has contributed to the total reflectance measure and that the reading obtained is not the true reflectance reading of the sample. However, in many cases, readings relative to a liquid standard will be valuable.

In the case of mirror-like samples where the specular reflectance is known to be a close approximation to the total reflectance, a more accurate reading may be obtained by tilting the sample with respect to the horizontal plane of the measuring aperture. Care should be taken to cover the sample with a black cloth under such conditions to prevent light from entering the housing. For a discussion of the standard methods for measuring the various kinds of reflectance, refer to Chapter 6 of the previously cited reference.

The accuracy of any method of numerical integration can be improved by increasing the number of ordinates employed. This is especially true for the measurement of highly selective samples such as filters which sometimes may have a complicated spectrophotometric curve.

For measuring this type of sample, it is suggested that one refer to the "Handbook of Colorimetry," published by the M.I.T. Technology Press, which includes tables of the wavelength for 30 and 100 selected ordinates.

FORM VALUES

The visual color of any material depends on the spectral distribution of the light reflected from it. When this is combined with the spectral data for the light source plus the spectral response of a standard observer, a

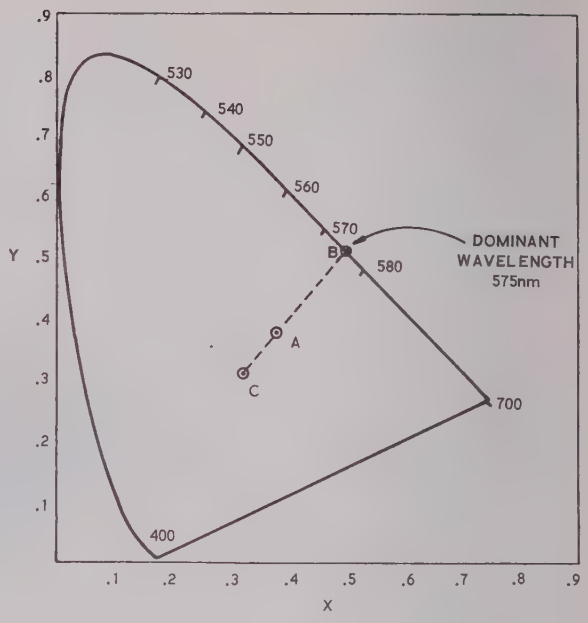


FIG. 19 - MAXWELL COLOR MIXTURE DIAGRAM

measurement of color is obtained. These values X, Y, Z (Tristimulus Values) plus the trichromatic coefficients x, y, are easily calculated from the computing form included with the instrument. Since it is not easy to visualize a color or a color difference from the above values, the general procedure is to plot y vs. x on a diagram known as the Maxwell Color Mixture Diagram.

In this diagram any point on the resulting curve represents the locus of the spectrum colors. That is, it is the line along which one would find the purest possible color for any one particular wavelength. The point C (x = .3101, y = .3163) is where the illuminant C (tungsten light) would fall; the point (A) (x = .3680, y = .3785) is the plot of the paint sample "Ivory Tan" when illuminated by illuminant C. The line from point C through point A intercepts the color diagram at about wavelength 575nm. This is the dominant wavelength of the color and is analogous to the concept of "HUE." The ratio of the distance (CA) to the distance from C to the curve is called the purity of color and is a measure of its saturation. The terms dominant wavelength and purity, together with brightness (the Y value), give a better concept of a color or color difference.

For example, two colors have the same x and y values but with a different Y would only differ in brightness. Two colors with the same (Y) plotted along the same line C would differ only in purity. Colors of different dominant wavelength would lie on different lines when plotted from the illuminant C.

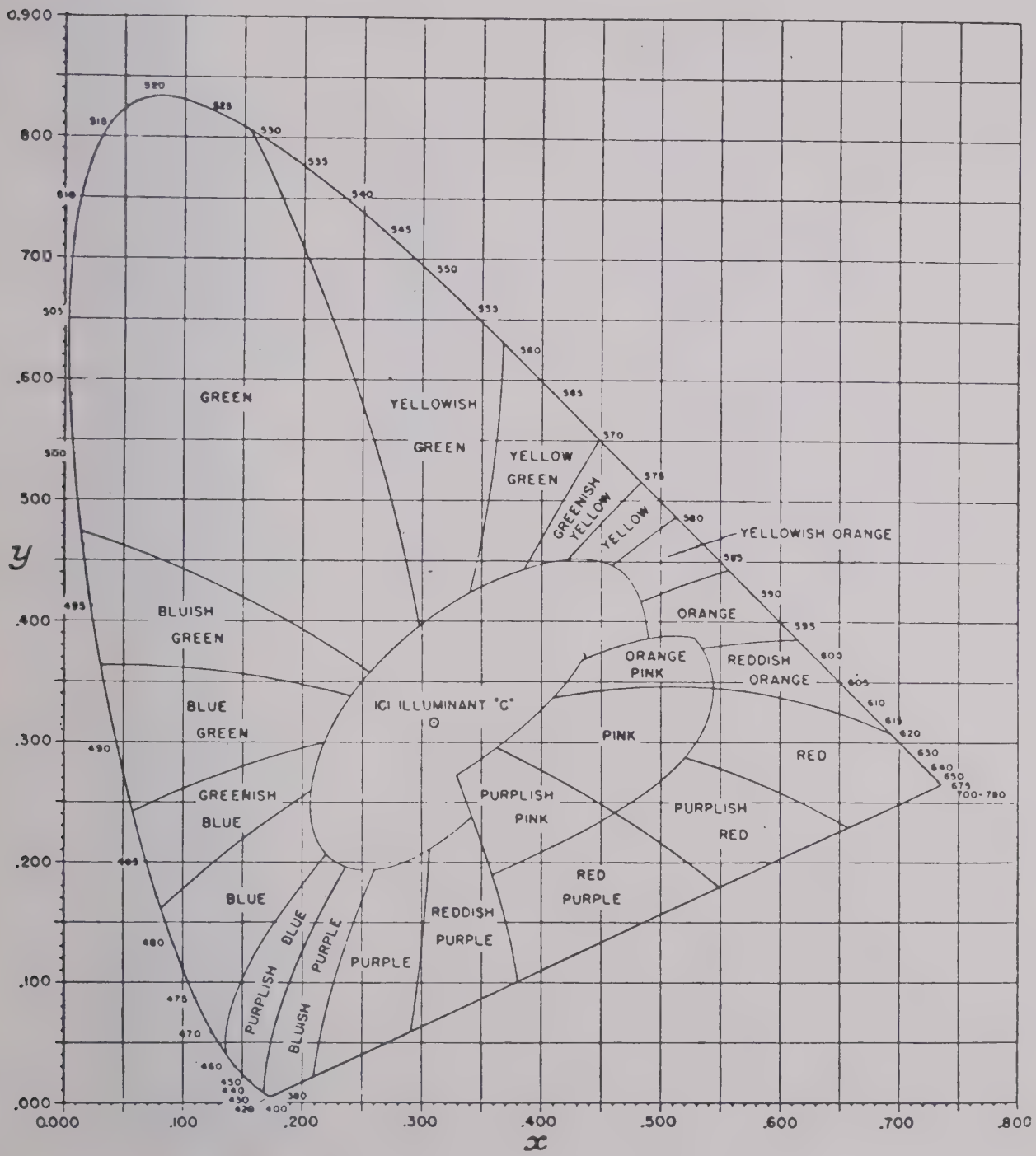


FIG. 20 - CHROMATICITY DIAGRAM

Maintenance

CAUTION

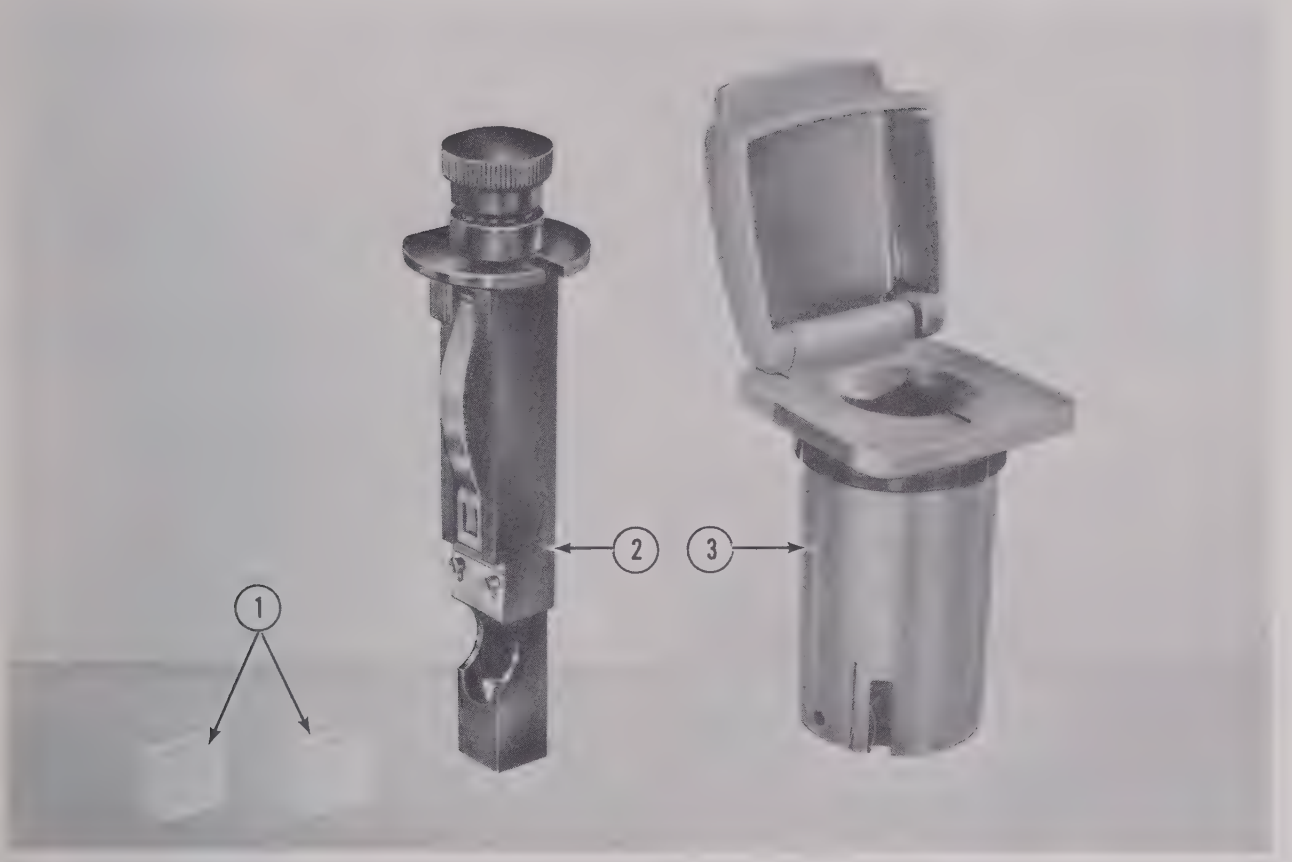
THERE ARE HIGH VOLTAGES WITHIN THIS EQUIPMENT. THE COVER SHOULD BE REMOVED BY QUALIFIED SERVICE PERSONNEL ONLY.

The most important aspect of optical maintenance is cleanliness. Dust and fingerprints on the porcelain standard, on the inside of the measuring sphere, or on the lens at the bottom of the sphere will lead to error in measurements and decrease the time required between calibrations of the porcelain standard.

SERVICE CHART
REFLECTANCE ATTACHMENT

TROUBLE	REMEDY
No sensitivity	1. Check power (pilot light comes on). 2. Check all electrical connections. 3. Check light transmission through measuring sphere. 4. Check meter zero (Zero Control). 5. Check tubes.
Low sensitivity	Check cleanliness of optical parts.
Needle fluctuations	Check ground wire for good contact.
Excessive drift or instability	Check stability of Spectronic 20 at "0%T."

Microcell Adapter Assembly
Cat. No. 33-29-14-01



1. Microcells 2. Adapter
3. Holder

FIG. 21 - MICROCELL ADAPTER ASSEMBLY

The complete Microcell Adapter Assembly consists of a 33-29-14 Adapter, a 33-29-16 Holder, and two 33-29-17 Microcells. The body of the adapter contains two positioning springs, which precisely locate the adapter in the holder. The microcell is held in the adapter by an internal spring which centers the microcell to the 1.25mm x 4.25mm aperture in the face of the adapter. To provide vertical alignment of this aperture with the light beam from the Spectronic 20 Monochromator, the seating ring may be positioned by loosening the set screw in the collar of the seating ring. (For detailed alignment procedures, refer to paragraph (a) in the following Maintenance Section.

The 33-29-17 Microcells are made of optical glass. The outside cell dimensions are 12.0mm x 12.5mm, providing a light path length of 10.0mm x 0.1mm. For convenient handling, the two sides perpendicular to the optically polished windows are provided with a ground surface. The sample volume required to fill the microcell is 0.2ml, but it can be used with approximately 0.1ml. Visually check the level in the cell after it is inserted into the adapter to insure that sufficient sample is present. With distilled water in the microcell, full scale deflection of the Spectronic 20 is obtained from 385nm - 600nm using the blue-sensitive phototube (33-29-71), and 600nm - 900nm

using the red-sensitive phototube (33-29-72) and red filter (33-29-18). On some of the older models a slightly narrower operating wavelength should be expected.

NOTE: The proper filters from the filter kit (33-31-28) can also be used.

OPERATION

1. Remove any sample adapter installed in the Spectronic 20. Insert the microcell holder into the instrument, seat firmly, and lock in position with the Allen-screw located on the inner wall of the Holder.

2. Select phototube/filter – as required.

3. Power ON, 5-minute warmup – Power Switch (Zero Control)

4. Select Wavelength – Wavelength Control

5. Close holder cover, set meter zero – Zero Control.

6. Fill microcell with reference blank, insert cell into adapter. CAUTION: Keep fingerprints off cell window.

7. Install adapter into holder.

8. Set 100%T on meter – 100%T Control.

9. Remove blank, insert unknown sample. Read %T or Abs. value on meter.

NOTE: For optimum accuracy, use the same microcell for the reference blank and the unknown sample. A series of readings should be obtained on the unknown and the results averaged.

MAINTENANCE

(a) When the microcell adapter is not in use, care should be taken to insure that its vertical adjustment is not accidentally changed since this could cause a reduction in sensitivity. If the seating ring should become loose, readjust as follows:

   1. Unscrew the knurled knob on the microcell adapter 1-2 turns.

   2. Loosen the set screw in the hub of the seating ring.

   3. Set 0%T on meter with the Zero Control.

   4. Install microcell adapter (with distilled water cell) into the microcell holder.

   5. Adjust the 100%T Control for a nominal 50%T meter reading.

   6. Adjust the vertical position of the adapter by pushing or pulling on the knurled knob until the maximum meter reading (%T) is obtained.

   7. Tighten the set screw to secure the seating ring.

(b) To prevent the possibility of corrosion, the holder and adapter should be rinsed with distilled water and dried before storage.

(c) The microcells should be thoroughly cleaned before each new determination. The end windows in the light path should be protected from scratches, fingerprints, and dirt.

Semi-Automatic Flow-Thru Unit Cat. No. 33-29-77-17

FIG. 22 - THE SEMI-AUTOMATIC FLOW-THRU UNIT

The Flow-Thru Unit consists of three compartments:

1. A Flow-Thru Cuvette Holder which is positioned in the sample compartment of the Spectronic 20 and rigidly holds the cuvette (0.2ml microcell) in the optical path of the Spectronic 20.

2. The Pump Housing containing a vibratory vacuum pump and a waste jar for temporary storage of liquids after measurement.

3. A probe for withdrawing samples from test tubes or similar containers.

In operation, sample is drawn into the microcell by inserting the probe into the sample and lightly pressing the button on top of the cuvette. The microcell fills in 4 seconds. A flow indicator in the probe tubing permits visual checking of sample flow. Depressing the button still further empties the sample from the sample cell into the storage jar, and also causes a shutter to fall into the light path so that no light falls on the Spectronic 20 phototube. Zero adjustments are made with this button fully depressed. For those applications involving very dense sample solutions, a Short Path Length Flow-Thru Cuvette, Cat. No. 33-29-97 is available. It provides a path length of 0.1mm to 1.0mm, and is readily interchangeable with the standard cuvette. Full instruction on the installation and operation of the Flow-Thru Unit are contained in a separate operator's manual shipped with each unit.

Concentration Computer Cat. No. 33-27-55

Using a Bausch & Lomb Concentration Computer as an accessory to the Spectronic 20 eliminates the tedious task of converting transmittance data into concentration data.

This accessory is a high sensitivity analog computer which automatically calculates the concentration of samples being analyzed and displays the concentration of the solute on a specially designed projection type meter. It is especially useful where

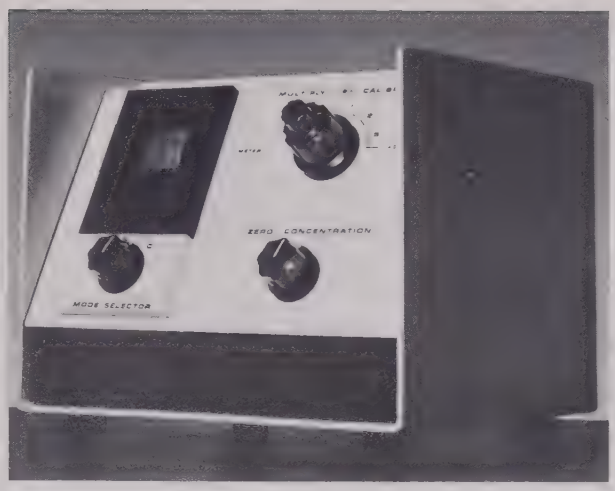


FIG. 23 - THE B&L CONCENTRATION COMPUTER

fast and accurate determinations of concentrations are necessary. Full instructions are supplied with each instrument.

VOM - Omniscribe Recorders and Patch Cords

VOM-5, CAT. NO. 39-03-06-31

The VOM-5 Strip Chart Recorder transcribes the DC analog voltage signal from the Spectronic 20. It features 17 recording ranges and instant selection of five chart speeds. Power requirements are 105 - 125 VAC, 60 Hz ONLY.

To connect the recorder to the 33-31-72 Regulated Model, order Patch Cord 33-26-71.

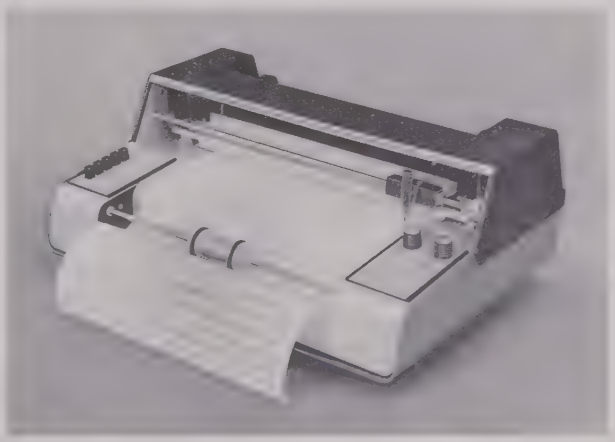


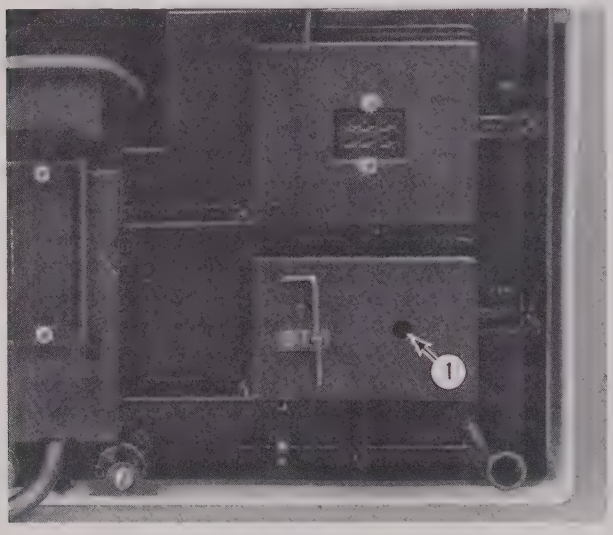
FIG. 24 - "OMNISCRIBE" RECORDER

If the recorder is to be used with the older models 33-29-61-64 or 33-29-59, order the Spectro Chart 27, Cat. No. 33-27-37.

"OMNISCRIBE" RECORDER
CAT. NO. 39-11-22

The Omniscribe Recorder provides a full 10-inch trace, four chart speeds up to 10 in./min., and multiple range options. Power requirements are 115/230 VAC, 50/60 Hz. This unit is compatible with the regulated model 33-31-72 ONLY, and requires Patch Cord, Cat. No. 33-26-74.

Spectronic 20 Analog Output Adjustment



1. Adjustment Control

FIG. 25 - ANALOG OUTPUT ADJUSTMENT

Spectronic 20 Analog Output Adjustment (33-31-72 Model Only)

The Analog (recorder) output signal level is 1.0 VDC (nominal) at a 100%T meter readout. If desired, the output signal level at 100%T may be varied from 0.0 to 1.0 VDC with a recessed control located on the bottom of the instrument. See Fig. 25.

Filter Kit Cat. No. 33-31-28

This kit consists of four filters which reduce stray light and second-order error to less than 0.5%T over the entire wavelength range, and a didymium filter used for wavelength calibration checks.

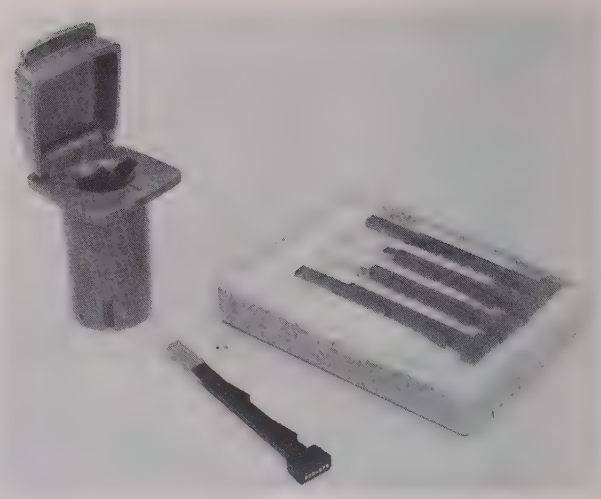


FIG. 26 - ACCESSORY FILTER KIT

INSTALLATION

Each of the filters is identified on the top edge of the filter holder. The four stray light and second-order filters are identified by their operating wavelength. The didymium filter is identified by name.

To use the filters, you must have a 1/2 inch test tube adapter, Cat. No. 33-31-27, which has a slot on the right-hand side of the top of the adapter. The filters are inserted into the slot, automatically placing the filter in the light path. Due to the shape of the filter holder, there is only one possible way to insert it into the adapter. When using the stray light and second-order filters, do NOT use either the 33-29-18 infrared filter or the 33-29-92 wide-range filter.

WAVELENGTH CALIBRATION CHECK

1. Set the instrument wavelength at 485nm. With test tube adapter empty, set 0%T on the meter. With distilled water in the test tube, set 100%T on the meter.

2. Leave the test tube filled with distilled water in the adapter, and place the didymium filter into the filter slot. Note the readout in % Transmittance.

3. Repeat steps 1 and 2 until readings have been recorded at 485nm, 490nm, 500nm, and 505nm.

4. The wavelength scale is properly adjusted when maximum transmittance occurs at 497nm ± 5nm.

5. Checks may also be performed at 528nm, 554nm, and at 582nm. Set the wavelength scale 10 to 15nm before these peaks and dips, take a reading every 5nm, and record the results as in steps 1, 2, 3, and 4. The wavelength scale is properly adjusted when maximum absorbance occurs at 528nm and at 582nm, or when maximum transmittance occurs at 497nm and at 554nm (all wavelengths given may vary ± 5nm). The specific transmittance values are not important. They will vary from filter to filter.

If the unit is out of calibration, refer to the "Service Procedures" for further information.

STRAY LIGHT/SECOND ORDER FILTER

The overall range of the instrument and the upper range of the blue phototube may be extended using the stray light and second order filters.

Although the instrument's design wavelength range is 240nm-950nm, in many cases there may be sufficient lamp/system energy available to allow use outside these limits. By using the appropriate stray light filter, the operator insures that any available radiation beyond the wavelength range of the instrument is limited to the selected wavelength only. The upper range of the blue phototube (CE-A59RX) can also be extended, in many cases, by using the 600nm-900nm stray light filter.

NOTE: THE MANUFACTURER OF OUR PHOTOTUBES GUARANTEES THE BLUE PHOTOTUBE (CE-A59RX) BETWEEN 340nm-600nm AND THE RED PHOTOTUBE (CE-A30) UP TO 950nm ONLY. THEREFORE, WE CANNOT GUARANTEE SPECTRAL RESPONSE BEYOND THESE LIMITS.

If you are unable to obtain a full scale (100%T) meter deflection with your reference solution, set the reference readout to half scale (50%T) on the meter and multiply all meter readings by 2X.

CARE OF FILTERS

The filters included in the Spectronic 20 Filter Kit are optical devices which form part of the Spectronic 20 optical system and require the same care as other optical components. Scratches and fingerprints on the surfaces of the filters can create unexpected error in analysis. When cleaning the filters, use a soft cloth or cleansing tissue. Do not submerge them in hot water, clean them with harsh chemicals, or subject them to any undue physical stress.

PUBLICATIONS

INDUSTRIAL METHODS MANUAL

The Industrial Methods Manual consists of several carefully formulated methods for the analysis of metal alloys and plating solutions. These publications are available at nominal cost in four separate sections - Aluminum Alloys, Steel Alloys, Copper Alloys and Plating Solutions. A handsome, leatherette-covered ring binder (33-29-02) is available to accommodate the sections.

SECTION 1. Aluminum Alloys, Cat. No. 33-29-03

Manganese by the Persulfate Method	0.05 to 2.00 percent manganese
Copper by the Diethyldithiocarbamate Method	0.10 to 8.00 percent copper
Nickel by the Dimethylglyoxime Method	0.01 to 2.50 percent nickel
Chromium by the Chromate Method	0.05 to 0.35 percent chromium
Iron by the O-Phenanthroline Method	0.05 to 1.50 percent iron
Bismuth by the Thiourea Method	0.10 to 0.50 percent bismuth

SECTION 2. Steel Alloys, Cat. No. 33-29-04

Manganese in Plain Carbon and low Alloy Steels (Periodate Method)	0.25 to 1.60 percent manganese
Nickel by the Dimethylglyoxime Method	0.5 to 3.5 percent nickel
Silicon by the Silicomolybdate Method	0.05 to 0.40 percent silicon
Molybdenum by the Thiocyanate-Stannous Chloride Method	0.05 to 0.40 percent molybdenum
Phosphorus by the Molybdenum-Blue Method	0.01 to 0.04 percent phosphorus
Chromium and Manganese, simultaneous determination in Steel	0.2 to 20.0 percent chromium 0.3 to 1.5 percent manganese
Copper by the Alpha-benzoinoxime Method	0.04 to 0.25 percent copper

SECTION 3. Copper Alloys, Cat. No. 33-29-05

Nickel by the Dimethyglyoxime Method	0.05 to 0.50 mg of nickel in 100 ml of solution
Manganese by the Periodate Method	0.3 to 3.0 mg of manganese in 100 ml of solution
Silicon by the Silicomolybdate Method	0.02 to 5.00 percent silicon
Iron by the Thiocyanate Method	0.1 to 1.0 mg of iron in 200 ml of solution
Phosphorus by the Molybdivanadophosphoric Method	0.2 to 1.0 mg of phosphorus in 100 ml of solution

SECTION 4. Plating Solutions, Cat. No. 33-29-06

Copper by the Copper II Tetrammine Method	0.06 to 6.0 grams copper in 1 liter of plating solution
Gold by the O-Tolidine Method	1.0 to 7.5 grams gold in 1 liter of plating solution
Nickel by the Dimethylgyloxime Method	0.2 to 1.2 grams nickel in 1 liter of plating solution
Phosphate by the Amino Naphthol Sulfonic Acid Method	0.5 to 3.0 grams phosphate in 1 liter of plating solution
Rhodium by the Stannous Chloride Method	1.0 to 5.0 grams rhodium in 1 liter of plating solution

Clinical Methods Manual, Cat. No. 33-29-91

A manual of 35 up-to-date methods of performing the most often used clinical laboratory spectrophotometric analyses. Spanish translations of above, Cat. No. 33-29-94.

Educational Manual, Cat. No. 33-29-09

A brief but comprehensive discussion of the theory and practical application of colorimetry and spectrophotometry.

Fundamentals of Spectrophotometry, Cat. No. 33-2019

Discusses the theory of absorption spectrophotometry, with emphasis on causes and avoidance of analytical errors. A brief bibliography is included.

Introduction To Spectroscopy, Cat. No. S-4036

An elementary guide describing the evolution of spectroscopic instrumentation, with a short discussion of spectrophotometer design and application in modern chemistry.

Accessory & Replacement Parts List

Accessories

Constant Voltage Transformer, for use with Standard Model Spectronic 20 where wide line voltage fluctuations occur	33-29-10
Concentration Computer with Cord Set to connect to Spectronic 20 (Regulated Models only)	33-27-55
Color Analyzer Reflectance Attachment for 2mm x 8mm area including: Magnesium Carbonate Block, Pack of 50 C.I.E. Trichromatic Charts and instructions	33-29-44-01
Color Analyzer Reflectance Attachment for 12mm x 12mm area including: Magnesium Carbonate Block, Pack of 50 C.I.E. Trichromatic Charts and instructions	33-99-5631
Pack of 50 C.I.E. Trichromatic Charts	33-29-12
Magnesium Carbonate White Reflectance Standard	33-29-13
Flow-Thru Cuvette Assembly, including: Flow-Thru Cuvette, pair of microcells, tubing, pump, and tantalum probe	33-29-77-17
Flow-Thru Cuvette only	33-29-77
Pump	33-29-79
Tantalum Probe	33-29-84
Tubing	33-29-99
Short Path Flow-Thru Cuvette Assembly, including: Short Path Flow-Thru Cuvette, Tantalum Probe, and Tubing (33-29-79 Pump must be ordered separately)	33-29-97-17
Short Path Flow-Thru Cuvette only	33-29-97
VOM-5 Recorder, including: One (1) 100 ft. Roll Chart Paper, Pens, Ink, Input Probe, and Operator's Manual	39-03-06-31

Accessories (Cont'd)

Spectro Chart 27 to adapt VOM Recorder to 33-29-61-64 & 33-29-59 Spectronic 20's only	33-27-37
Patch Cord to connect VOM Recorder to 33-31-72 Spectronic 20 only	33-26-71
Omniscribe Recorder including one roll Chart Paper, 4 Ink Cartridges, Instruction Manual	39-11-22
Patch Cord to connect Omniscribe Recorder to 33-31-72 Spectronic 20 only	33-26-74

Glassware & Adapters

Microcell Assembly including adapter, holder and pair of microcells	33-29-14-01
Microcell Adapter to accept 33-29-17 Microcells	33-29-14
Microcell Holder to accept 33-29-14 Adapter	33-29-16
Pair of Microcells(0.2ml volume) for 33-29-77-17 and 33-29-14-01 Assemblies	33-29-17
1/2" Test Tubes, Box of 1 dozen	33-29-27
Adapter for 1/2" Test Tubes	33-31-27
3/4" Test Tubes, Box of 1 dozen (requires 33-29-31 Adapter and 33-29-32 Light Shield)	33-29-37
Adapter for 3/4" Test Tubes (requires 33-29-32 Light Shield)	33-29-31
1" Test Tubes; Box of 1 dozen (requires 33-29-30 Adapter and 33-29-32 Light Shield)	33-29-34
Adapter for 1" Test Tubes (requires 33-29-32 Light Shield)	33-29-30
Light Shield for use with 3/4" and 1" Test Tubes	33-29-32
1/2" Square Cuvettes, Pkg. of 2 (requires 33-29-49 Adapter)	33-29-33
Adapter for 1/2" Square Cuvettes	33-29-49
Test Tube Rack to hold six (6) 1/2" Test Tubes and six (6) 1/2" Square Cuvettes	33-29-21
Dosimeter Plate Holder	33-29-23

Phototubes & Filters

Blue Sensitive Phototube	33-29-71
Infrared Sensitive Phototube (requires 33-29-18 Infrared Filter)	33-29-72
Infrared Filter	33-29-18
Wide Range Phototube (requires 33-29-92 Filter)	33-29-89
Wide Range Filter	33-29-92
Accessory Filter Kit (4 stray light/2nd order filters, 1 didymium filter)	33-31-28

Lamps

Pilot Lamps for 33-29-61 Series and 33-29-95 Spectronic 20 (Box of 10)	33-33-69
Exciter Lamp for 33-29-40 & 33-29-42 Spectronic 20's	33-33-68
Exciter Lamp for 33-29-61 Series, 33-29-59, 33-29-95, 33-31-71, and 33-31-72 Spectronic 20's (Box of 10)	33-33-85

Manuals

Industrial Method Manual, Ring Binder only	33-29-02
Aluminum Alloys Section	33-29-03
Steel Alloys Section	33-29-04
Copper Alloys Section	33-29-05
Gold & Gold Alloys Section	33-29-06
Educational Manual	33-29-09
Clinical Methods Manual (English)	33-29-91
Clinical Methods Manual (Spanish)	33-29-94
Service Manual	33-31-46
Introduction to Spectroscopy	S-4036
Fundamentals of Spectrophotometry	33-2019

ANALYTICAL SYSTEMS DIVISION
REGIONAL SERVICE CENTERS

EASTERN

Bausch & Lomb
Analytical Systems Division
36 Midvale Road
Mountain Lakes, New Jersey 07046
(201) 335-7601

Bausch & Lomb
Analytical Systems Division
565 Commonwealth Avenue
Boston, Massachusetts 02215
(617) 262-6100

Bausch & Lomb
Analytical Systems Division
820 Linden Avenue
Rochester, New York 14625
(716) 385-1000

CENTRAL

Bausch & Lomb
Analytical Systems Division
340 Melvin Drive
Northbrook, Illinois 60062
(312) 498-0400

WESTERN

Bausch & Lomb
Analytical Systems Division
2571 Merced Street
San Leandro, California 94577
(415) 351-5400

EUROPEAN HEADQUARTERS

Bausch & Lomb GmbH
Analytical Systems Division
Munchner Strasse 2
8043 Munchen Unterfoehring
Germany

SOUTHERN

Bausch & Lomb
Analytical Systems Division
2131 Kingston Court, S.E.
Marietta, Georgia 30062
(404) 422-9061

Bausch & Lomb
Analytical Systems Division
10215 Fernwood Road
Bethesda, Maryland 20034
(301) 530-9006

CANADA

Bausch & Lomb Canada
Analytical Systems Division
1790 Birchmount Road
Scarborough M1P 2H7, Ontario, Canada
(416) 291-7911

Bausch & Lomb Canada
Analytical Systems Division
2605 Paulus Street
Montreal 386, Quebec, Canada
(514) 336-1633

Bausch & Lomb Canada
Analytical Systems Division
880 Wellington Street
Ottawa K1R 6K7, Ontario, Canada
(613) 232-0142

INTERNATIONAL SALES OFFICE

Analytical Systems Division products are available in most countries.

For information write:

Bausch & Lomb Incorporated
Analytical Systems Division
820 Linden Avenue
Rochester, New York 14625

BAUSCH & LOMB ROCHESTER, NEW YORK 14625
ANALYTICAL SYSTEMS DIVISION

MP MASTER
MA33164

333171-10001

Printed in U.S.